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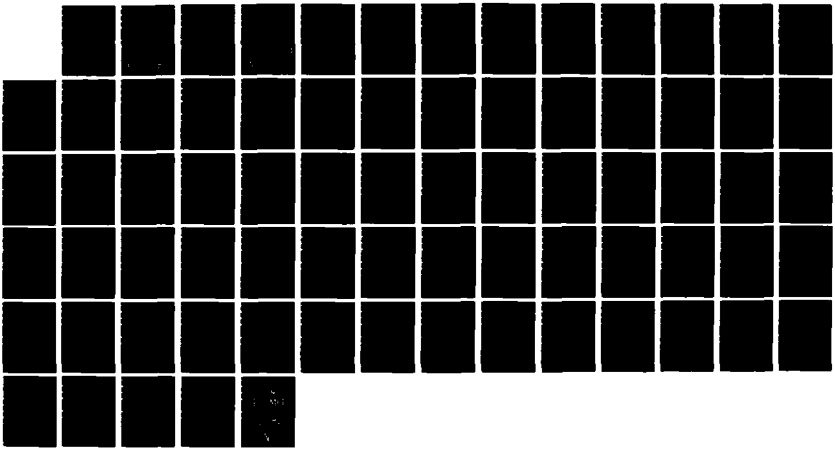

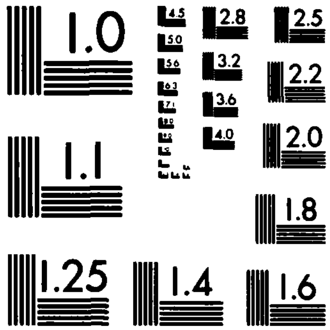

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APPLIED MARINE RESEARCH LABORATORY
OLD DOMINION UNIVERSITY
NORFOLK, VIRGINIA 23508

TOXINS IN THE VICINITY OF THE PROPOSED NORFOLK DISPOSAL SITE

By

Raymond W. Alden III,
Principal Investigator

Guy J. Hall and Joseph H. Rule
Co-Principal Investigators

Supplemental Contract Report
For the period ending November 1984

Prepared for the
Department of the Army
Norfolk District, Corps of Engineers
Fort Norfolk, 803 Front Street
Norfolk, Virginia 23510

Under
Contract DACW65-81-C-0051
Work Order No. 0016

February 1985

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Levels of toxins (PNAH's and CHC's) in water, sediment and biota were very low, usually below detection limits. Mercury values in water were elevated but source unknown.

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TOXINS IN THE VICINITY OF THE PROPOSED NORFOLK DISPOSAL SITE

By

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INTRODUCTION

Dredging activities are considered essential to the functioning of most ports in maintaining navigational channels. The major question concerning these operations is not if they should be continued, since it is obvious that channels must be maintained and developed. Rather, the question most frequently addressed concerns where to dispose the dredged material with the least possible ecological impact. Onshore, landfill disposal operations often create a number of socio-economic and ecological problems in the wetlands surrounding ports. In fact, any land available for such activities in a highly urbanized port city are cost prohibitive. Therefore, a great deal of interest is being focused on the feasibility of open ocean disposal of dredged materials as an ecologically sound alternative to onshore disposal. (Pequegnat _et al_., 1978).

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This project represents an overview of a portion of a on-going multidisciplinary program initiated by the Ocean Dumping Program of the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Army Corps of Engineers (COE). Its purpose is to assess the potential ecological impact of open ocean disposal of materials dredged from Hampton Roads, Virginia, a highly industralized seaport. Since 1981, investigators associated with the Applied Marine Research Laboratory at Old Dominion University have conducted extensive analytical testing to assess the chemical, geological and biological patterns at the disposal site under baseline conditions, so that models could be developed for future trend assessment studies. The major focus of this paper concerns the overall findings of chemical toxins (heavy metals, chlorinated hydrocarbons, and polynuclear aromatic hydrocarbons) in water, sediment and tissue samples from the Norfolk Disposal Site Baseline Monitoring Program.

STUDY AREA AND GENERAL SAMPLING REGIME

The area designated the Norfolk Disposal Site (NDS) is a potential dredge material disposal site delineated by a circle with a radius of 7.4 km centered at 36°59'N latitude and 75°39'W longitude in the coastal waters off the mouth of the Chesapeake Bay. The Site is located beyond the 10-fathom depth contour line, approximately 27 km east of the Cape Henry Channel (Figs. 1a,b). Permanent monitoring stations have been established in and around the disposal site.

Sediment Quality Survey:

In recognition of the role sediments play in accumulating organic toxins, the EPA has recommended an extensive baseline survey of these chemicals in the sediments of the region of any proposed disposal site.

Samples were collected for chemical analysis from the NDS in 1982. They were taken in triplicate with a Shipek grab from 15 stations randomly selected from a grid of sites covering the Site at 1 km intervals (Fig. 1). This collection regime paralleled that of a previous semi-quantitative survey of the organic toxins in NDS sediments (Alden *et al*., 1981, 1982). Standard methods for the preservation and handling of samples, as outlined by EPA (1980) and Grice *et al*. (1972) were rigorously followed.

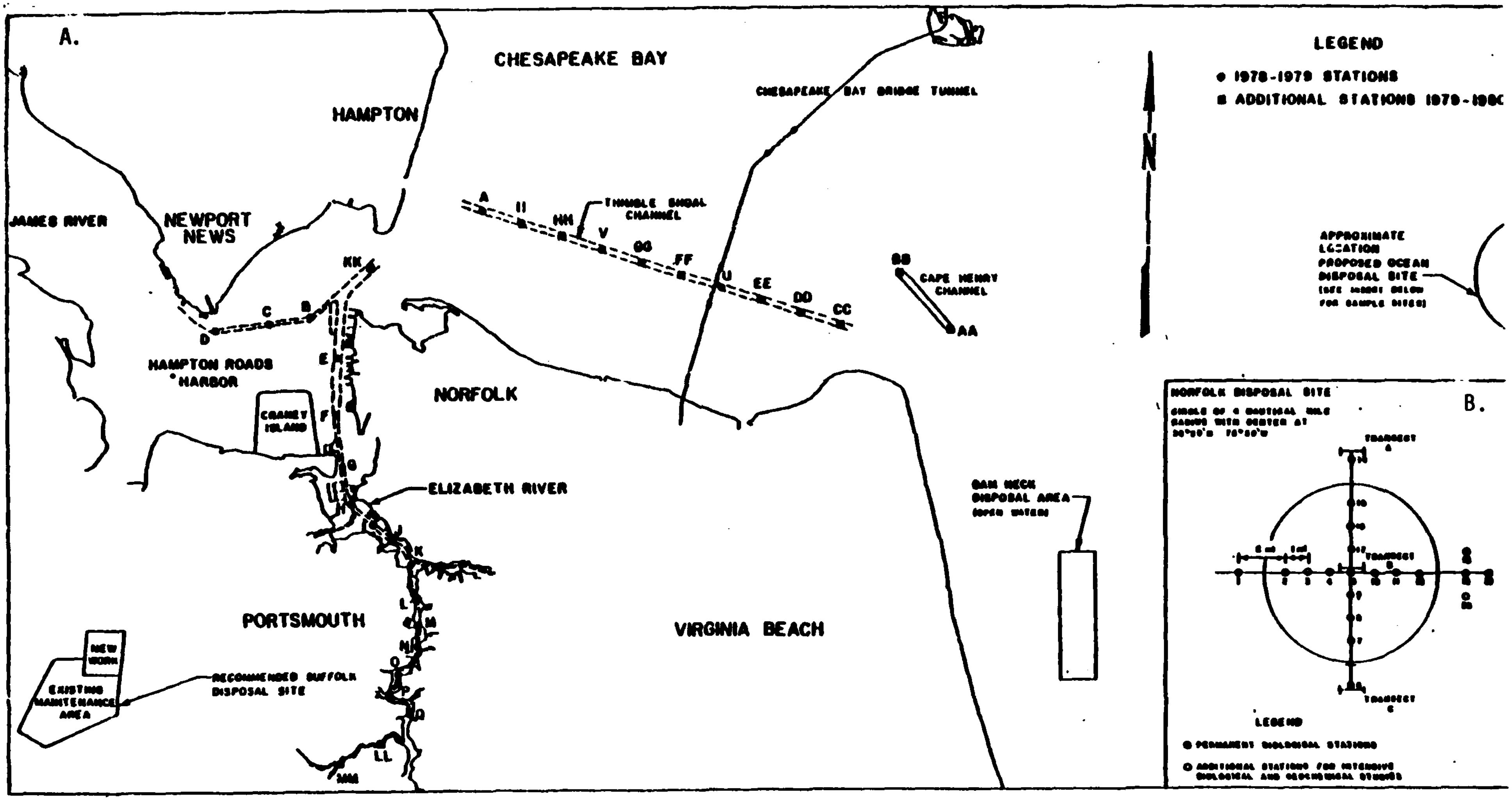

Figure 1. Study area. Single letters represent inshore collection sites for the present study. Norfolk Site, Dam Neck Site, and Craney Island Facility are also indicated.
Inset: Study area at the Norfolk Site. Solid circles represent offshore biological collection sites. Transects A, B, C, are trawl stations.

Bioaccumulation Monitoring Program:

Concern over the bioaccumulation of toxins in biota and any potential impacts on food chains, including man, has led the EPA to recommend the monitoring of selected biological groups during baseline or trend assessment studies (EPA/COE, 1978). Accordingly, representative organisms from demersal and epibenthic groups required by EPA guidelines (EPA/COE, 1978) were selected from collections made at Stations 5 and 14 for the Benthic Monitoring Program (dredge and otter trawls). Zooplankton, the final group, was collected at stations by oblique bongo (351 um mesh nets) tows. Triplicate samples (or composites) were collected for each group at both stations and frozen in the field with dry ice.

Water Quality Monitoring:

Contaminants such as heavy metals, chlorinated hydrocarbons (CHC's), and polynuclear aromatic hydrocarbons (PNAH's) are not very soluble in water. Over the long term, high concentrations of these substances end up being absorbed by suspended solids, and then subsequently deposited in bottom sediments. There has been great concern that dredging and open-water disposal may "re-release" these trapped contaminants the to water column. Consequently, these operations could potentially damage the environmental quality of coastal ecosystems.

For this reason, surface and bottom samples (one meter below the

surface and one meter above the bottom) were collected at the center station (5) and northern-most station (14) (Fig. 1b). Water samples were collected in triplicate at each depth using teflon lined go-flow bottles. All samples were analyzed for heavy metals, PNAH's and CHC's.

ANALYTICAL METHODS

Polynuclear Aromatic Hydrocarbon Analysis

Sediments:

Sediment samples collected in the field were stored at -20°C in methanol-rinsed 8 oz. glass jars with teflon lined caps until the PNAH analyses were performed. Prior to the extraction, the internal standard (1,1-binaphthyl), was pipeted onto the air-dried sediment. The sediment sample was then soxhlet extracted for 24 hours according to Brown et al. (1980). The extract was then concentrated to 1 ml using a Buchler rotary evaporator and the solvent gradually changed to hexane. Silisic acid columns were employed for the separation of non-aromatic components from the 16 polynuclear aromatic hydrocarbons. This type of silica gel column topped with sodium sulfate and alumina has proven to be quite successful and reproducible in sample clean-up (Boehm, 1980). The first fraction eluted from the column contained the non-aromatic constituents and was discarded. The second fraction contained the PNAH's of interest. This fraction was concentrated in a 70°C water bath under dry nitrogen to 1.0 ml and stored until analyzed by high pressure liquid chromatography (HPLC) or gas chromatography (GC). The identities of toxins in selected (i.e. unusually high or questionable) samples of all matrices were confirmed with gas chromatographic mass spectrometry (GC/MS).

Biological Tissues:

Tissue samples collected in the field were wrapped in methanol washed aluminum foil and stored on dry ice until returning ashore where they were frozen at -20°C until the PNAH analyses were performed. After thawing, 15-25 grams (wet weight) of muscle tissue was removed from each organism and spiked with 1,1 binaphthyl. Samples were then saponified in 10 N KOH for 24 hours. Digested samples were extracted three times with hexane and centrifuged at 3500 rpms to remove emulsions. Hexane extracts were then concentrated to 0.5 ml and resaponified with a methanolic potassium hydroxide mixture for 2 hours in a 100°C water bath. Samples were then re-extracted with hexane and added to a separatory funnel where they were cleaned up with 10 ml of 25% DMSO/water. The final volume of hexane was adjusted to 5 ml and each frozen until analyzed by HPLC or GC.

Water:

Samples were collected using five or eight liter teflon lined go-flow bottles and transferred to methanol-rinsed four liter amber storage bottles. Water samples were taken in triplicate at each sampling site, refrigerated at 4°C and analyzed for PNAH's within 48 hours of sampling.

Extraction methods followed those outlined by the EPA Federal Register in Method 610 (December 3, 1979). A sample volume of

1500 ml was extracted with triplicate rinses of dichloromethane. Extracts were dried over a column of sodium sulfate and concentrated to 1 ml using a Buchler rotary evaporator. The samples were then archived until analyzed by HPLC or GC.

Chlorinated Hydrocarbon Analysis

All sediment tissue and water samples analyzed for CHC's were subsampled from material collected and preserved for PNAH analysis.

Sediment:

All sediments were air dried spiked with Dieldrin, and 20 grams (dry weight) analyzed by soxhlet extracting for 24 hours using 200 ml of methanol benzene (1:1) (EPA, 1980). After extracting, the sediment was discarded and the solvents switched to benzene while concentrating to a final volume of 2 ml. Samples at this point were screened on a gas chromatograph equipped with an electron capture detector (ECD). When background level interferences were excessive, extracts were cleaned up on a florisil column capped with 1.6 grams of sodium sulfate. The final fraction was taken to 2 ml under dry nitrogen and treated with activated copper to remove sulfur interference. All samples were quantitated and on a packed or capillary ECD gas chromatograph.

Tissue:

The analysis of tissues for CHC's was performed as outlined by EPA (1980) in Section 5(A)2. Prior to the analysis of each tissue sample, a subsample was taken for wet weight/dry weight determination.

Water:

Water samples were analyzed for CHC's as specified by the EPA Federal Register (December 3, 1979) Method 608. Minor modifications were made to enhance the recovery of several compounds and reduce the level of background interference. Water samples ranging from 1000 to 1500 ml were extracted in triplicate with dichloromethane. Prior to extraction on internal standard (Dieldrin) was introduced to aid in evaluating the recovery efficiency of each analysis. The extracts were then dried over a column of sodium sulfate and concentrated to dryness on a rotary evaporator.

Samples were then brought up to 5 ml using hexane and reconcentrated to 1 ml using dry nitrogen. All samples were stored frozen until analyzed by ECD gas chromatography equipped with either capillary or packed columns.

Heavy Metal Analysis

Tissue Digestion:

The methods for analysis of metals in biological tissues were modified from the procedure developed by the Region II EPA Laboratory. Biological tissue samples of 0.5-g dry weight were placed in micro-Kjeldahl flasks and allowed to stand overnight with 10 ml of concentrated, redistilled nitric acid (HNO_3). The digestates were boiled until approximately 3-5 ml remained. The flasks were cooled, and 3 ml of 30% hydrogen peroxide (H_2O_2) were added to each dropwise. The digestates were boiled to near dryness and, if residues remained, an additional 5 ml of HNO_3 and 3 ml of H_2O_2 were added for additional digestion. Following a cooling period, 5 ml of HNO_3 and 30 ml of DI H_2O were added and the flasks reheated to dissolve any salts. The digestates were then diluted to an appropriate volume with DI H_2O.

Water Extraction:

Trace metals were extracted from the water samples using DPAC-MIBK methods modified from Standard Methods (APHA, 1979) and determined by flame atomic absorption spectrophotometry.

RESULTS

Toxins in Water

Seasonal water collections were made in 1981, 1982 and 1983 at two stations in the vicinity of NDS. Triplicate surface and bottom water samples were analyzed for heavy metals and organic toxins. The results of the heavy metals analyses are presented in Table I. A series of MANOVAs indicated that there were no significant patterns for any of the metals (when above detection levels) with respect to depth (surface vs. bottom) or geographic location (NDS vs. the northern peripheral station). The metal concentrations in the water were quite low, but certain values changed seasonally: slightly higher values tended to occur during the summer. The 1983 metal levels tended to be somewhat greater than the 1982 concentrations. Lead, nickel, cadmium and zinc exhibited slightly elevated values during the 1983 summer cruise. Unexpectedly high concentrations of mercury were also found in the summer of 1983. This phenomenon was confirmed by water samples taken throughout the lower Chesapeake Bay and coastal waters, and confirmed by two laboratories.

The organics in water analysis indicated that the levels of PNAH's and CHC's in the vicinity of NDS were quite low. The concentrations of PNAH's were either low (ng/l) or below detection limits (BDL) (Table II).

TABLE I. Concentrations of total metals in waters from NDS. Values represent means of 12 samples (standard errors). Values are in µg/1.

	1981					1982				1983			
Metal	Mar	Apr	Jun	Aug	Oct	Jan	Apr	Aug	Oct	Feb	Apr	Jul	Dec
Cd	<0.6	<0.6	<0.6	0.8 (0.05)	0.7 (0.06)	<1.0	<1.0	0.3 (0.3)	<1.0	<1.0	<1.0	4.5 (2.8)	2.1 (0.8)
Cu	<2.0	<2.0	<2.0	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	0.8 (0.3)	0.4 (0.2)
Hg	-	-	-	-	-	0.33 (0.08)	0.27 (0.08)	<0.2	<0.2	<0.2	0.5 (0.07)	3.1 (0.38)	-
Ni	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.3 (0.5)	2.5 (0.9)
Pb	<2.0	<2.0	<2.0	<2.0	<2.0	<9.0	<9.0	<9.0	<9.0	<9.0	<9.0	14.1 (1.1)	11.8 (1.2)
Zn	<1.0	<1.0	1.3 (0.6)	6.7 (0.7)	3.6 (0.38)	<1.0	<1.0	1.8 (1.8)	<1.0	<1.0	<1.0	11.8 (6.1)	3.8 (0.9)

TABLE II. Concentrations of PNAH (μg/1) in water from NDS. Values represent means of 12 samples (standard errors).

	1982				1983			
	Jan	Apr	Aug	Oct	Feb	Apr	Jul	Dec
Naphthalene (N)	<1.8	807.48 (456.50)	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
Acenaphthylene (Acy)	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3
Acenaphthene (Acn)	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
Fluorene (F)	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21
Phenanthene (Ph)	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
Anthracene (A)	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66
Fluoranthene (FL)	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21
Pyrene (P)	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27
Benzo(a)anthracene (BaA)	<0.013	<0.013	77.70 (77.70)	<0.013	<0.013	<0.013	<0.013	<0.013
Chrysene (C)	<0.15	<0.15	215.23 (159.74)	<0.15	<0.15	<0.15	<0.15	<0.15
Benzo(b)Fluoranthene (BbFL)	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018
Benzo(k)fluoranthene (BkFL)	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017
Benzo(a)pyrene (BaP)	<0.023	<0.023	<0.023	<0.023	<0.023	<0.023	<0.023	<0.023
Dibenzo(a,h)anthracene (DBA)	<0.030	<0.030	35.26 (19.15)	<0.030	<0.030	<0.030	<0.030	<0.030
Indenopyrene (IP)	<0.043	<0.043	<0.043	<0.043	<0.043	<0.043	<0.043	<0.043
Benzo(g,h,i)perylene (BPR)	<0.076	<0.076	<0.076	<0.076	<0.076	<0.076	<0.076	<0.076

The CHC's in water were non-detectable throughout the study. (See Table III for detection limits.) In October, 1983, the GC analysis indicated a combination of contaminants in the water samples from Station 5. However, GC/MS analysis showed that the contaminants were various aliphatic hydrocarbons, rather than ether PNAH's or CHC's.

Toxins in Sediments

In 1982, triplicate sediment samples were collected from 15 stations which were previously surveyed in 1981. The PNAH's in sediments were all below detection limits except for napthalene, which when detected, was in the low ppb (ng/g) (Table IV). Likewise, the CHC's were very low (i.e. pg/g to low ng/g) (Table V). The most ubiquitous compounds were DDT and its metabolities. The remaining pesticides were found only sporadically and in trace amounts.

Toxins in Tissues

Biotic collections were made in and around NDS during each seasonal cruise. One major observation which can be made as a result of these collections is that the NDS region is characterized by a paucity of epibenthic and demersal biota. At times, sufficient biomass could not be collected for the full range of analyses on each of the representative taxonomic groups, despite extended trawls (3 trawls of up to 30 minutes each). Quite often, various species within each general group were used

TABLE III. Detection limits (ng/a) for chlorinated hydrocarbons in water.

	1982				1983			
	Jan	Apr	Aug	Oct	Feb	Apr	Jul	Dec
Aldrin	<10	<20	<31	<31	< 4	< 4	< 4	< 4
α-BHC	<10	<20	<31	<31	< 3	< 3	< 3	< 3
Lindane	<10	<20	<31	<31	< 4	< 4	< 4	< 4
Heptachlor epoxide	<10	<20	<31	<31	< 83	< 83	< 83	< 83
Kepone	<30	<60	<93	<93	<185	<185	<185	<185
o,p-DDT	<30	<40	<62	<62	< 12	< 12	< 12	< 12
p,p-DDD	<20	<40	<62	<62	< 4	< 4	< 4	< 4
p,p-DDT	<20	<40	<62	<62	< 12	< 12	< 12	< 12
p,p-DDE	<20	<40	<62	<62	< 11	< 11	< 11	< 11

TABLE IV. Concentrations of PNAH (ng/g) in sediments from NDS. Values represent the means of 3 replicas from each station (standard errors).

Quadrant	Site	N	Acy	Acn	F	Ph	A	FL	P	BaA	C	DBA	BPR	BaP	BbFL	BkFL	IP
NE	15	71.20 (71.20)	<175 (-)	<175 (-)	<100 (-)	<100 (-)	<75 (-)	<75 (-)	<50 (-)	<62 (-)	<50 (-)	<25 (-)	<50 (-)	<50 (-)	<62 (-)	<50 (-)	<50 (-)
	G5	<175 (-)	<175 (-)	<175 (-)	<100 (-)	<100 (-)	<75 (-)	<75 (-)	<50 (-)	<62 (-)	<50 (-)	<25 (-)	<50 (-)	<50 (-)	<62 (-)	<50 (-)	<50 (-)
	G11	142.3 (142.3)	<175 (-)	<175 (-)	<100 (-)	<100 (-)	<75 (-)	<75 (-)	<50 (-)	<62 (-)	<50 (-)	<25 (-)	<50 (-)	<50 (-)	<62 (-)	<50 (-)	<50 (-)
	24	<175 (-)	<175 (-)	<175 (-)	<100 (-)	<100 (-)	<75 (-)	<75 (-)	<50 (-)	<62 (-)	<60 (-)	<25 (-)	<50 (-)	<50 (-)	<62 (-)	<50 (-)	<50 (-)
	11	136.9 (136.9)	<175 (-)	<175 (-)	<100 (-)	<100 (-)	<75 (-)	<75 (-)	<50 (-)	<62 (-)	<50 (-)	<25 (-)	<50 (-)	<50 (-)	<62 (-)	<50 (-)	<50 (-)
SE	28	<175 (-)	<175 (-)	<175 (-)	<100 (-)	<100 (-)	<75 (-)	<75 (-)	<50 (-)	<62 (-)	<50 (-)	<25 (-)	<50 (-)	<50 (-)	<62 (-)	<50 (-)	<50 (-)
	8	<175 (-)	<175 (-)	<175 (-)	<100 (-)	<100 (-)	<75 (-)	<75 (-)	<50 (-)	<62 (-)	<50 (-)	<25 (-)	<50 (-)	<50 (-)	<62 (-)	<50 (-)	<50 (-)
SW	G24	147.8 (147.8)	<175 (-)	<175 (-)	<100 (-)	<100 (-)	<75 (-)	<75 (-)	<50 (-)	<62 (-)	<50 (-)	<25 (-)	<50 (-)	<50 (-)	<62 (-)	<50 (-)	<50 (-)
	G25	<175 (-)	<175 (-)	<175 (-)	<100 (-)	<100 (-)	<75 (-)	<75 (-)	<50 (-)	<62 (-)	<50 (-)	<25 (-)	<50 (-)	<50 (-)	<62 (-)	<50 (-)	<50 (-)
	26	372.7 (372.7)	<175 (-)	<175 (-)	<100 (-)	<100 (-)	<75 (-)	<75 (-)	<50 (-)	<62 (-)	<50 (-)	<25 (-)	<50 (-)	<50 (-)	<62 (-)	<50 (-)	<50 (-)
	G16	105.0 (105.0)	<175 (-)	<175 (-)	<100 (-)	<100 (-)	<75 (-)	<75 (-)	<50 (-)	<62 (-)	<50 (-)	<25 (-)	<50 (-)	<50 (-)	<62 (-)	<50 (-)	<50 (-)
	14	163.8 (163.8)	<175 (-)	<175 (-)	<100 (-)	<100 (-)	<75 (-)	<75 (-)	<50 (-)	<62 (-)	<50 (-)	<25 (-)	<50 (-)	<50 (-)	<62 (-)	<50 (-)	<50 (-)

TABLE IV. (Continued)

Quadrant	Site	N	Acy	Acn	F	Ph	A	FL	P	BaA	C	DBA	BPR	BaP	BbFL	BkFL	IP
NW	G6	<175 (-)	<175 (-)	<175 (-)	<100 (-)	<100 (-)	<75 (-)	<75 (-)	<50 (-)	<62 (-)	<50 (-)	<25 (-)	<50 (-)	<50 (-)	<62 (-)	<50 (-)	<50 (-)
	22	<175 (-)	<175 (-)	<175 (-)	<100 (-)	<100 (-)	<75 (-)	<75 (-)	<50 (-)	<62 (-)	<50 (-)	<25 (-)	<50 (-)	<50 (-)	<62 (-)	<50 (-)	<50 (-)
Center	5	<175 (-)	<175 (-)	<175 (-)	<100 (-)	<100 (-)	<75 (-)	<75 (-)	<50 (-)	<62 (-)	<50 (-)	<25 (-)	<50 (-)	<50 (-)	<62 (-)	<50 (-)	<50 (-)
TOTAL		162.6 (100.2)	<175	<175	<100	<100	<75	<75	<50	<62	<50	<25	<50	<50	<62	<50	<50

TABLE V. Concentrations of chlorinated hydrocarbons (ng/g) in sediments from NDS. Values represent the means of 3 replicates from each station (standard errors).

Quadrant	Site	α-BHC	Lindane	Aldrin	Heptachlor Epoxide	Kepone	p,p-DDT	o,p-DDT	o,p-DDD	p,p-DDE	ΣDDD
NE	15	<6.2 (-)	<6.2 (-)	<6.2 (-)	<6.2 (-)	<18.7 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)
	G5	<6.2 (-)	<6.2 (-)	<6.2 (-)	<6.2 (-)	<18.7 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)
	G11	<6.2 (-)	<6.2 (-)	<6.2 (-)	<6.2 (-)	<18.7 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)
	24	<6.2 (-)	<6.2 (-)	<6.2 (-)	<6.2 (-)	<18.7 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)
	11	<6.2 (-)	<6.2 (-)	<6.2 (-)	<6.2 (-)	<18.7 (-)	0.98 (0.98)	<12.5 (-)	<12.5 (-)	0.53 (0.53)	1.52 (1.52)
SE	28	<6.2 (-)	<6.2 (-)	<6.2 (-)	<6.2 (-)	1.26 (1.26)	11.67 (6.09)	34.75 (26.33)	<12.5 (-)	8.82 (8.57)	55.23 (37.52)
	8	<6.2 (-)	<6.2 (-)	1.65 (1.65)	2.68 (1.90)	1.59 (0.29)	8.92 (1.97)	6.13 (3.37)	<12.5 (-)	0.60 (0.04)	15.65 (3.54)
SW	G24	<6.2 (-)	<6.2 (-)	<6.2 (-)	<6.2 (-)	<18.7 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)
	G25	<6.2 (-)	<6.2 (-)	<6.2 (-)	<6.2 (-)	<18.7 (-)	1.78 (0.89)	<12.5 (-)	<12.5 (-)	14.06 (2.51)	15.83 (2.12)
	26	<6.2 (-)	<6.2 (-)	<6.2 (-)	<6.2 (-)	<18.7 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)
	G16	<6.2 (-)	<6.2 (-)	<6.2 (-)	<6.2 (-)	<18.7 (-)	7.74 (7.74)	<12.5 (-)	<12.5 (-)	1.83 (1.83)	13.38 (13.83)
	G14	<6.2 (-)	<6.2 (-)	<6.2 (-)	<6.2 (-)	<18.7 (-)	<12.5 (-)	<12.5 (-)	<12.5 (-)	0.93 (0.47)	0.93 (0.47)

TABLE V. (Continued)

Quadrant	Site	α-BHC	Lindane	Aldrin	Heptachlor Epoxide	Kepone	p,p-DDT	o,p-DDT	o,p-DDD	p,p-DDE	ΣDDD
NW	G6	<6.2 (-)	<6.2 (-)	4.49 (2.31)	4.70 (2.52)	<18.7 (-)	2.85 (1.62)	1.44 (1.44)	<12.5 (-)	1.44 (0.52)	5.73 (0.84)
	22	<6.2 (-)	<6.2 (-)	<6.2 (-)	<6.2 (-)	<18.7 (-)	3.78 (2.38)	<12.5 (-)	<12.5 (-)	<12.5 (-)	3.78 (2.38)
Center	5	<6.2 (-)	<6.2 (-)	<6.2 (-)	6.43 (1.39)	1.08 (0.98)	1.78 (1.78)	<12.5 (-)	<12.5 (-)	0.45 (0.23)	2.23 (1.88)
TOTAL		<6.2	<6.2	0.41 (0.24)	0.92 (0.35)	2.04 (1.06)	2.95 (0.80)	3.07 (1.97)	<12.5	1.91 (0.77)	7.93 (3.04)

opportunistically: those species collected in enough abundance on any given cruise were analyzed. A listing of all species collected during the study, along with the overall mean concentrations of the toxins in tissues of each are presented in the Appendix.

The levels of heavy metals in the representative groups for the seasonal cruises are presented in Table II. No distinct periodic patterns were apparent, although several peak values were noted. The fish tissue samples generally contained lower concentrations of metals than did the epibenthic macroinvertebrates, which, in turn, were lower than the zooplankton samples.

Organic toxins in the representative biotic groups are presented in Tables VII and VIII for PNAH's and CHC's, respectively: The PNAH's were usually below detection limits. In February and April of 1983, some of the macroinvertebrates and zooplankton samples exhibited detectable but moderately low concentrations (i.e., low ppm; ug/g) of some of the heavier PNAH's. The levels found during these periods were also quite variable, often with only a single replicate within each taxonomic group exhibiting detectable concentrations. The CHC's were also generally below detection limits, and were extremely low when detectable (i.e., ppb; ng/g). The DDT breakdown product, p,p-DDE was the chlorinated hydrocarbon most frequently observed in the fish and macroinvertebrate tissues.

TABLE VI. Concentrations of metals (μg/g) in the tissues of representative taxonomic groups from NDS. Values represent the means of 6 samples (standard errors).

Taxonomic Group	Metal	1981 Mar	1981 Apr	1981 Jun	1981 Aug	1981 Oct	1982 Jan	1982 Apr	1982 May	1982 Oct	1983 Feb	1983 Apr	1983 Jul	1983 Dec
Fish	Cd	<0.9 (-)	<0.9 (-)	1.40 (.38)	<0.9 (-)	- -	<0.9 (-)	0.9 (-)	<0.9 (-)	-	1.52 (.21)	- -	<0.9 (-)	- -
	Cr	20.18 (5.43)	11.04 (1.00)	7.15 (7.15)	5.04 (1.93)	- -	2.81 (1.17)	5.75 (3.07)	<3.0 (-)	-	6.36 (2.36)	- -	<3.0 (-)	- -
	Cu	7.39 (1.00)	5.64 (1.00)	7.07 (0.19)	7.39 (3.85)	- -	18.02 (1.99)	3.62 (1.82)	16.41 (5.23)	-	11.71 (2.53)	- -	29.2 (1.5)	- -
	Fe	163.93 (29.22)	108.99 (1.00)	57.62 (22.72)	75.94 (21.59)	- -	70.52 (9.85)	54.29 (4.55)	57.28 (5.25)	-	42.47 (13.86)	- -	25.65 (10.55)	- -
	Mn	11.25 (3.30)	5.54 (1.00)	<3.0 (-)	4.37 (1.53)	- -	13.05 (2.52)	3.96 (3.30)	7.46 (2.22)	-	11.81 (2.46)	- -	15.85 (5.55)	- -
	Ni	4.45 (2.53)	<3.0 (-)	16.55 (16.55)	2.80 (1.27)	- -	31.99 (10.84)	3.10 (0.91)	6.56 (3.81)	-	7.22 (1.09)	- -	15.00 (3.60)	- -
	Pb	7.75 (2.44)	<2.0 (-)	<2.0 (-)	6.66 (3.23)	- -	10.61 (3.15)	3.89 (1.80)	14.70 (14.25)	-	7.34 (2.12)	- -	6.45 (6.45)	- -
	Zn	115.24 (25.03)	75.96 (1.00)	76.67 (5.85)	64.07 (14.12)	- -	82.77 (7.52)	50.17 (12.09)	51.68 (9.51)	-	91.67 (45.40)	- -	49.05 (5.05)	- -

TABLE VI. (Continued)

Taxonomic Group	Metal	1981 Mar	1981 Apr	1981 Jun	1981 Aug	1981 Oct	1982 Jan	1982 Apr	1982 May	1982 Oct	1983 Feb	1983 Apr	1983 Jul	1983 Dec
Macroinvertebrates	Cd	-	<0.9	<0.9	<0.9	-	<0.9	0.73	<0.9	<0.9	3.14	-	9.9	-
		-	(-)	(-)	(-)	-	(-)	(0.73)	(-)	(-)	(0.37)	-	(1.0)	-
	Cr	-	6.15	<3.0	<3.0	-	41.33	<3.0	<3.0	<3.0	9.95	-	<3.0	-
		-	(3.07)	(-)	(-)	-	(23.40)	(-)	(-)	(-)	(9.95)	-	(-)	-
	Cu	-	24.53	23.75	74.34	-	41.56	29.08	50.90	35.55	100.25	-	115.25	-
		-	(13.09)	(4.94)	(9.80)	-	(10.86)	(1.00)	(15.60)	(12.75)	(14.75)	-	(9.55)	-
	Fe	-	97.14	33.38	13.80	-	53.33	30.17	73.78	22.65	44.55	-	713.2	-
		-	(22.58)	(13.68)	(2.70)	-	(15.71)	(1.00)	(3.12)	(3.55)	(18.75)	-	(206.1)	-
	Mn	-	2.18	4.01	<3.0	-	5.06	2.11	10.31	6.21	18.30	-	28.6	-
		-	(2.18)	(3.54)	(-)	-	(2.09)	(1.00)	(1.81)	(1.52)	(15.10)	-	(8.6)	-
	Ni	-	<3.0	2.56	3.56	-	3.00	3.72	2.07	7.54	55.36	-	27.05	-
		-	(-)	(.80)	(.73)	-	(2.47)	(1.00)	(1.52)	(2.67)	(49.64)	-	(2.55)	-
	Pb	-	2.07	<2.0	3.22	-	10.10	<2.0	<2.0	<2.0	<2.0	-	<2.0	-
		-	(2.07)	(-)	(3.22)	-	(4.27)	(-)	(-)	(-)	(-)	-	(-)	
	Zn	-	159.76	144.45	195.25	-	127.23	58.02	111.66	65.15	199.7	-	18.80	-
		-	(59.05)	(74.3)	(53.32)	-	(18.22)	(1.00)	(63.27)	(23.35)	(108.3)	-	(3.60)	

TABLE VI. (Continued)

Taxonomic Group	Metal	1981 Mar	1981 Apr	1981 Jun	1981 Aug	1981 Oct	1982 Jan	1982 Apr	1982 May	1982 Oct	1983 Feb	1983 Apr	1983 Jul	1983 Dec
Zooplankton	Cd	1.54 (.97)	8.21 (.58)	4.45 (1.04)	<0.9 (-)	0.57 (.27)	3.85 (1.84)	<0.9 (-)	- -	4.51 (.30)	- -	<0.9 (-)	<0.9 (-)	- -
	Cr	5.38 (3.50)	9.95 (4.15)	12.20 (7.74)	31.66 (7.35)	13.31 (7.36)	566.66 (283.80)	2.00 (1.31)	- -	11.50 (2.97)	- -	2.48 (2.39)	44.95 (31.41)	- -
	Cu	39.11 (15.62)	90.06 (29.98)	943.24 (736.61)	10.15 (4.79)	11.20 (2.34)	63.20 (29.51)	11.94 (2.40)	- -	51.29 (19.10)	- -	26.96 (8.00)	103.87 (87.50)	- -
	Fe	5611.11 (1786.94)	3034.98 (1101.37)	2065.48 (460.95)	6136.25 (2278.36)	2109.71 (317.80)	3694.50 (1380.53)	325.61 (77.86)	- -	579.67 (106.79)	- -	719.97 (114.20)	1750.92 (768.51)	- -
	Mn	63.29 (25.24)	82.58 (18.55)	56.92 (21.75)	58.66 (13.95)	33.29 (6.22)	115.08 (55.06)	11.32 (1.77)	- -	21.03 (2.98)	- -	28.20 (3.30)	62.43 (27.01)	- -
	Ni	25.38 (13.78)	71.63 (26.28)	17.93 (17.93)	<3.0 (-)	1.56 (1.56)	2.68 (1.71)	16.22 (7.81)	- -	2.4 (2.4)	- -	2.52 (2.50)	15.70 (15.30)	- -
	Pb	12.53 (4.16)	126.66 (83.22)	128.16 (71.30)	11.18 (11.18)	9.81 (3.29)	61.02 (15.33)	1.60 (1.60)	- -	56.56 (31.57)	- -	17.68 (6.54)	71.02 (51.23)	- -
	Zn	934.99 (559.77)	1428.22 (336.53)	1859.35 (438.32)	2991.88 (524.52)	1004.42 (442.19)	909.17 (180.05)	216.29 (6.50)	- -	199.84 (33.53)	- -	- -	- -	- -

TABLE VII. Concentrations of PNAH (ng/g) in the tissues of representative taxonomic groups from NDS. Values represent the means of 6 samples (standard errors).

Taxonomic Group	PNAH	1982 Jan	1982 Apr	1982 May	1982 Oct	1983 Feb	1983 Apr	1983 Jul	1983 Dec
Fish	Napthalene (N)	<0.037	10.00 (5.31)	<0.037	<0.037	<0.037	<0.037	<0.037	.046 (.030)
	Acenaphthylene (Acy)	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014
	Acenaphthene (Acn)	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	.029 (.029)
	Fluorene (F)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Phenanthene (Ph)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Anthracene (A)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Fluoranthene (FL)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Pyrene (P)	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Benzo(a)anthracene (BaA)	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017
	Chrysene (C)	<0.037	<0.037	<0.037	<0.037	<0.037	<0.037	<0.037	<0.037
	Benzo(b)fluoranthene (BbFL)	<0.028	<0.028	<0.028	<0.028	0.33 (0.33)	<0.028	<0.028	.032 (.032)

TABLE VII. (Continued)

Taxonomic Group	PNAH	1982 Jan	1982 Apr	1982 May	1982 Oct	1983 Feb	1983 Apr	1983 Jul	1983 Dec
Fish	Benzo(k)fluoranthene (BkFL)	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016
	Benzo(a)pyrene (BaP)	<0.012	<0.012	<0.012	<0.012	1.05 (0.55)	11.09 (11.09)	<0.012	<0.012
	Dibenzo(a,h)anthracene (DBA)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	Indenopyrene (IP)	<0.051	<0.051	<0.051	<0.051	<0.051	<0.051	<0.051	<0.051
	Benzo(g,h,i)perylene (BPR)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.47 (0.32)

TABLE VII. (Continued)

Taxonomic Group	PNAH	1982 Jan	1982 Apr	1982 May	1982 Oct	1983 Feb	1983 Apr	1983 Jul	1983 Dec
Macroinvertebrate	Napthalene (N)	187.68 (155.87)	<0.037	<0.037	<0.037	<0.037	<0.037	<0.037	0.28 (0.28)
	Acenaphthylene (Acy)	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014
	Acenaphthene (Acn)	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012
	Fluorene (F)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Phenanthene (Ph)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Anthracene (A)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Fluoranthene (FL)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Pyrene (P)	<0.004	<0.004	<0.004	<0.004	<0.004	3.46 (0.96)	<0.004	<0.004
	Benzo(a)anthracene (BaA)	<0.017	<0.017	<0.017	<0.017	<0.017	2.11 (2.11)	<0.017	<0.017
	Chrysene (C)	<0.037	<0.037	0.03 (0.03)	<0.037	<0.037	<0.037	0.22 (0.22)	<0.037
	Benzo(b)fluoranthene (BbFL)	<0.028	<0.028	<0.028	<0.028	<0.028	1.72 (1.72)	<0.028	<0.028

TABLE VII. (Continued)

Taxonomic Group	PNAH	1982 Jan	1982 Apr	1982 May	1982 Oct	1983 Feb	1983 Apr	1983 Jul	1983 Dec
Macroinvertebrate	Benzo(k)fluoranthene (BkFL)	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016
	Benzo(a)pyrene (BaP)	<0.012	<0.012	<0.012	<0.012	4.11 (4.11)	3.19 (0.04)	<0.012	<0.012
	Dibenzo(a, h)anthracene (DBA)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	Indenopyrene (IP)	<0.051	<0.051	<0.051	<0.051	<0.051	<0.051	<0.051	<0.051
	Benzo(g,h,i)perylene (BPR)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

TABLE VII. (Continued)

Taxonomic Group	PNAH	1982 Jan	1982 Apr	1982 May	1982 Oct	1983 Feb	1983 Apr	1983 Jul	1983 Dec
Zooplankton	Napthalene (N)	60.58 (55.15)	0.54 (0.49)	29.94 (27.84)	<0.037	<0.037	<0.037	<0.037	<0.037
	Acenaphthylene (Acy)	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014
	Acenaphthene (Acn)	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012
	Fluorene (F)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Phenanthene (Ph)	<0.002	<0.002	<0.002	<0.002	<0.002	0.55 (0.36)	<0.002	<0.002
	Anthracene (A)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Fluoranthene (FL)	<0.003	<0.003	<0.003	<0.003	6.88 (6.88)	6.00 (0.94)	<0.003	<0.003
	Pyrene (P)	<0.004	<0.004	<0.004	<0.004	12.33 (12.33)	3.20 (1.60)	<0.004	<0.004
	Benzo(a)anthracene (BaA)	<0.017	<0.017	<0.017	<0.017	5.92 (5.92)	11.22 (7.16)	<0.017	<0.017
	Chrysene (C)	<0.037	<0.037	<0.037	<0.037	<0.037	7.32 (7.32)	<0.037	<0.037
	Benzo(b)fluoranthene (BbFL)	<0.028	<0.028	<0.028	<0.028	14.22 (14.22)	<0.028	0.68 (0.42)	<0.028

TABLE VII. (Continued)

Taxonomic Group	PNAH	1982 Jan	1982 Apr	1982 May	1982 Oct	1983 Feb	1983 Apr	1983 Jul	1983 Dec
Zooplankton	Benzo(k)fluoranthene (BkFL)	<0.016	<0.016	<0.016	<0.016	92.53 (92.53)	<0.016	<0.016	<0.016
	Benzo(a)pyrene (BaP)	<0.012	<0.012	<0.012	<0.012	<0.012	0.98 (0.98)	<0.012	<0.012
	Dibenzo(a,h)anthracene (DBA)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	Indenopyrene (IP)	<0.051	<0.051	<0.051	<0.051	<0.051	3.15 (3.15)	<0.051	<0.051
	Benzo(g,h,i)perylene (BPR)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

TABLE VIII. Concentrations of chlorinated hydrocarbons (ng/g) in the tissues of representative taxonomic groups from the NDS. Values represent the means of 6 samples (standard errors).

Taxonomic Group	Pesticide	1981 Mar	1981 Apr	1981 Jun	1981 Aug	1981 Oct	1982 Jan	1982 Apr	1982 May	1982 Oct	1983 Feb	1983 Apr	1983 Jul	1983 Dec
Fish	α-BHC	< 83	< 83	< 83	< 83	< 83	< 60	< 60	< 60	< 60	9.90 (4.07)	10.00 (10.00)	10.00 (10.00)	26.14 (16.19)
	Lindane	< 83	< 83	< 83	< 83	< 83	< 60	< 60	< 60	< 60	8.92 (4.77)	< 4	< 4	6.19 (6.19)
	Aldrin	< 83	< 83	< 83	< 83	< 83	< 60	< 60	< 60	< 60	< 4	< 4	< 4	< 4
	Heptachlor-epoxide	< 83	< 83	< 83	< 83	< 83	< 60	< 60	< 60	< 60	8.87 (7.87)	16.67 (16.67)	45.00 (35.00)	< 4
	Kepone	<250	<250	<250	<250	<250	<180	<180	<180	<180	<12	<12	<12	<12
	o,p-DDT	<166	<166	<166	<166	<166	<120	<120	<120	<120	< 8	< 8	< 8	< 8
	o,p-DDD	<166	<166	<166	<166	<166	91.88 (81.78)	<120	<120	<120	49.07 (29.91)	< 8	< 8	< 8
	p,p-DDT	<166	<166	<166	<166	<166	308.75 (265.99)	<120	<120	<120	< 8	< 8	< 8	< 8
	p,p-DDE	212.73 (72.00)	<166	<166	<166	<166	68.75 (68.75)	<120	<120	<120	233.54 (103.30)	< 8	45.00 (5.00)	46.32 (42.27)
	β-BHC (1983)	-	-	-	-	-	-	-	-	-	35.06 (13.55)	< 4	< 4	45.80 (45.80)
	Dieldrin (1983)	-	-	-	-	-	-	-	-	-	< 4	< 4	< 4	26.82 (11.77)
	Heptachlor (1983)	-	-	-	-	-	-	-	-	-	< 4	< 4	< 4	< 4

TABLE VIII. (Continued)

Taxonomic Group	Pesticide	1981 Mar	1981 Apr	1981 Jun	1981 Aug	1981 Oct	1982 Jan	1982 Apr	1982 May	1982 Oct	1983 Feb	1983 Apr	1983 Jul	1983 Dec
Macroinvertebrate	α-BHC	-	< 83	< 83	< 83	< 83	< 60	-	< 60	< 60	9.52 (4.78)	13.33 (3.33)	< 4	47.06 (6.92)
	Lindane	-	< 83	< 83	< 83	< 83	< 60	-	< 60	< 60	< 4	< 4	< 4	37.83 (26.41)
	Aldrin	-	63.33 (31.80)	< 83	< 83	< 83	< 60	-	< 60	< 60	< 4	< 4	< 4	< 4
	Heptachlor-epoxide	-	< 83	< 83	< 83	< 83	< 60	-	< 60	< 60	< 4	< 4	< 4	< 4
	Kepone	-	<250	<250	<250	<250	<180	-	<180	<180	<12	<12	<12	<12
	o,p-DDT	-	<166	<166	<166	<166	<120	-	<120	<120	< 8	< 8	< 8	(15.23) (15.23)
	o,p-DDD	-	<166	<166	<166	<166	<120	-	<120	<120	< 8	< 8	< 8	< 8
	p,p-DDT	-	<166	<166	<166	<166	<120	-	<120	<120	< 8	< 8	< 8	< 8
	p,p-DDE	-	<166	<166	<166	<166	<120	-	<120	<120	< 8	23.33 (6.67)	40.00 (20.00)	134.44 (134.44)
	β-BHC (1983)	-	-	-	-	-	-	-	-	-	< 4	< 4	< 4	< 4
	Dieldrin (1983)	-	-	-	-	-	-	-	-	-	< 4	< 4	< 4	< 4
	Heptachlor (1983)	-	-	-	-	-	-	-	-	-	< 4	< 4	< 4	< 4

TABLE VIII. (Continued)

Taxonomic Group	Pesticide	1981 Mar	1981 Apr	1981 Jun	1981 Aug	1981 Oct	1982 Jan	1982 Apr	1982 May	1982 Oct	1983 Feb	1983 Apr	1983 Jul	1983 Dec
Zooplankton	α-BHC	< 83	< 83	< 83	< 83	< 83	< 60	< 60	-	< 60	< 4	43.33 (12.56)	-	11.61 (11.61)
	Lindane	< 83	< 83	< 83	< 83	< 83	< 60	< 60	-	< 60	< 4	98.33 (34.97)	-	< 4
	Aldrin	< 83	< 83	< 83	< 83	< 83	< 60	< 60	-	< 60	< 4	81.67 (52.43)	-	< 4
	Heptachlor-epoxide	< 83	< 83	< 83	< 83	< 83	< 60	< 60	-	< 60	< 4	< 4	-	< 4
	Kepone	<250	<250	<250	<250	<250	<180	<180	-	<180	<12	<12	-	<12
	o,p-DDT	<166	<166	<166	<166	<166	<120	<120	-	<120	542.45 (542.45)	< 8	-	< 8
	o,p-DDD	<166	<166	<166	<166	<166	<120	<120	-	<120	< 8	< 8	-	< 8
	p,p-DDT	<166	<166	<166	<166	<166	<120	<120	-	<120	150.00 (150.00)	< 8	-	1267.15 (326.15)
	β-BHC (1983)	-	-	-	-	-	-	-	-	-	< 4	< 4	-	< 4
	Dieldrin (1983)	-	-	-	-	-	-	-	-	-	1045.91 (898.12)	< 4	-	< 4
	Heptachlor (1983)	-	-	-	-	-	-	-	-	-	< 4	< 4	-	< 4

Minimum Detectable Impacts of Contaminants

In order to determine the levels of toxins which would represent statistically detectable impacts at NDS, minimum detectable impacts (MDI) values were calculated for single samples and for cruise means as described by Alden (1984). The MDI's, and lowest concentrations required for impact detection are presented in Table IX. The MDI calculations were not made for toxins which were below detection limits for most or all of the study (e.g. most metals in water; organics in water and tissues; and most PNAH's in sediments). Of course, it is not necessary to use statistics for such cases since any impact which elevates the concentrations consistently above detection limits would be apparent. Due to the low levels of most of the toxins and the great degree of variability, and skewness of the data, (i.e., many values below detection limits which were treated as zeros for calculation purposes), most of the MDI values were quite high.

The MDI values ranged from 80% to over 1000%. Maximum limits of 3000% and 1000% were employed in the calculation of MDI values for single samples and cruise means, respectively, due to computer time requirements for the iterations involved in the estimation of extremely large MDI's. The very patchy and variable distribution of organics in sediments produced large MDI values. However, even an order of magnitude change in the values would produce values still well within the ppb range.

TABLE IX. Mean concentrations MDI's and lowest concentrations required for impact detection.

Matrix	Contaminant	Unit	Concentration	Impacted Sample Value	Sample MDI %	Impacted Cruise Mean Value	Cruise Mean MDI %
Water	Hg	(µg/l)	0.6	5.3	860	1.2	95
Sediment	Napthalene	(ng/g)	164.0	864.0	425	336.0	105
	Aldrin	(ng/g)	0.4	6.9	1590	> 4.0	>1000
	Heptachlor epoxide	(ng/g)	0.9	10.3	1020	> 9.0	>1000
	Kepone	(ng/g)	2.0	24.5	1105	>20.0	>1000
	o,p-DDT	(ng/g)	3.1	>95.3	>3000	>31.0	>1000
	p,p-DDT	(ng/g)	3.0	>91.3	>3000	17.0	1000
	p,p-DE	(ng/g)	1.9	>59.2	>3000	>19.0	>1000
Fish	Cd	(µg/g)	0.5	3.9	620	3.1	490
	Cr	(µg/g)	6.9	46.4	570	19.3	180
	Cu	(µg/g)	10.9	57.9	430	19.62	80
	Fe	(µg/g)	74.3	304.8	310	245.2	230
	Mn	(µg/g)	8.8	50.1	470	19.4	120
	Ni	(µg/g)	10.1	98.3	870	39.4	290
	Pb	(µg/g)	8.9	74.8	740	24.9	180
	Zn	(µg/g)	78.9	449.5	470	291.9	270
Macro-invertebrate	Cd	(µg/g)	1.5	6.0	310	5.7	280
	Cr	(µg/g)	8.4	99.7	1090	>84.0	>1000
	Cu	(µg/g)	51.5	144.2	180	103.0	100
	Fe	(µg/g)	111.2	422.4	280	600.5	440
	Mn	(µg/g)	8.2	26.2	220	14.8	80
	Ni	(µg/g)	9.8	59.1	500	98.0	1000
	Pb	(µg/g)	2.3	16.0	610	23	1000
	Zn	(µg/g)	127.6	536.0	320	331.8	160

TABLE IX. (Continued)

Matrix	Contaminant	Unit	Concentration	Impacted Sample Value	Sample MDI %	Impacted Cruise Mean Value	Cruise Mean MDI %
Zooplankton	Cd	(μg/g)	2.4	13.2	450	9.6	300
	Cr	(μg/g)	74.7	1255.7	1580	448.2	500
	Cu	(μg/g)	147.6	3350.3	2170	767.5	420
	Fe	(μg/g)	2895.0	16790.7	480	11724.8	305
	Mn	(μg/g)	57.5	264.7	360	132.3	130
	Ni	(μg/g)	23.3	246.7	960	228.3	880
	Pb	(μg/g)	56.5	846.9	1400	237.3	320
	Zn	(μg/g)	1224.9	6859.6	460	2694.8	120

The mean concentrations and estimated "impacted" values of mercury in sea water were in the low ppb (ug/l) range. The mean and "impacted" concentrations of metals in fish tissues were in the low ppm (ug/g) range. The values for macroinvertebrates tissues were higher than those found for the fish while the zooplankton concentrations were the greatest. The single sample MDI's and impacted values for the zooplankton samples were quite high for metals such as copper, iron and zinc. This trend is primarily due to sporadically high concentrations in single samples observed throughout the study period.

DISCUSSION

The waters in the vicinity of NDS appear to have very low concentrations of organic toxins. This is not too surprising since the PNAH's and CHC's have a fairly low solubility in sea water and there are no apparent sources of these contaminants in the vicinity. Keizer and Gordon (1973) and Gordon *et al*. (1974) report that the concentration of total aromatics in coastal waters are in the low parts per billion (ppb) range. The PNAH's in the water were either below detection limits or, on the few occasions when detectable, in the low ppb (ug/l) range. The CHC's were non-detectable throughout the study. Petroleum contamination in the water samples was observed during the October 1983 cruise. Although there were none of the "priority pollutants" present, and the concentrations of the organics could be considered to be "trace," it is interesting to note that these measurements were taken during two fairly unique events at NDS. A series of 20 "test dumps" were made at NDS, and a number of coal colliers were moored nearby during this period. Whether either or both of these events were related to the oil in the water is open to speculation.

The metals in water were quite low in 1981 and 1982. The concentrations were either below detection limits or towards the lower end of the range of values reported for Chesapeake Bay and coastal waters by Kester and Courant (1973). In 1983, metal

concentrations were slightly elevated during the July cruise. Mercury concentrations exceeded the reference levels established by the EPA and the Virginia State Water Control Board for marine waters (VSWCB, 1976) on several occasions. Lead, cadmium, zinc and nickel were also somewhat elevated, but they did not approach the reference levels. However, concentration of all of these metals were within the ranges reported by Bryan (1984) in his review of metal levels in coastal and estuarine waters. The cause of the elevated mercury levels is unknown. A more extensive survey of Bay and coastal waters during the summer of 1983 indicated that the elevated mercury levels were widespread and increased towards the Chesapeake Bay. Therefore, it is suspected that the metals contamination may be from a regional source in the Bay.

The organic toxins in the sediments from NDS were quite low. Naphthalene was the only PNAH found at the site above detection limits . It was sporadically found in trace amounts (i.e., low ppb; ng/g) at various sites. Chlorinated hydrocarbons were also below detection levels for many samples, with DDT and its metabolities being the compounds most consistently found. Even the values above detection limits were extremely low, in the parts per trillion to low parts per billion range. The only apparent geographic pattern of distribution was that sediments from stations in the northeastern quadrant were observed to contain consistently lower levels of CHC's than those taken from the other quadrants. This quadrant was the one observed to be the least

impacted by the Chesapeake Bay plume (Alden et al., 1984). Perhaps this slight contamination pattern is related to the degree of impact from Bay sources.

The organic toxins in biota were extremely low. The PNAH's were only very rarely found, and then only in trace amounts. The CHC's were likewise quite low, but were more often detectable in the tissues, primarily due to the great sensitivity of the EC detector. As with the sediment samples, the DDT metabolities were the CHC's which were most often observed in the tissues. As was reported by Stickney et al. (1975) for biota collected in southeastern estuaries, there was no apparent relationship between the concentrations of these compounds in the fish and those found in the epibenthic macroinvertebrates. The concentrations of DDT and its metabolitics were lower in the biota of the present study than those reported by Stickney et al. (1975). However, this pattern is not unexpected since the present study was conducted many years after these chlorinated pesticides were banned.

One of the most obvious patterns with respect to heavy metals in tissues is the high degree of variability of concentrations. The most apparent cause for the variability is the fact that samples consisted of many different taxa. It is well known that bioaccumulation patterns of individual species are often very different. This phenomenon can be observed clearly in the data for individual samples. Elevated levels of cadmium, copper, iron,

manganese, and nickel were observed in the macroinvertebrate samples in July of 1983. These samples consisted of tissues taken from specimens of *Cancer irroratus*. It is apparent that this species had higher levels of these metals than the invertebrates which were more often collected at NDS. (e.g. the sand shrimp, *Crangon septemspinosa*) These concentrations were toward the upper end of the range reported for decapod crustaceans by Bryan (1984). The fact that the higher values were probably naturally occuring is attested by the fact that the levels of cadmium, copper and iron were similar to those reported for *Cancer* crabs in the review by Eisler (1984). Some of the invertebrate samples analyzed in February 1983 exhibited elevated levels of cadmium, copper and nickel. These samples consisted of tissues from the squid *Loligo pealei*. Martin and Flegal (1975) reported that various species of squid are capable of concentrating copper to "incredibly high levels" in the production of their respiratory pigments and that other heavy metals are often accumulated in the process.

The zooplankton samples were the most variable and often exhibited the highest concentrations of heavy metals. The fact that the amount of tissue available for analysis is often limited in zooplankton samples leads to high variability since the slightest variations in metal concentrations are greatly magnified in the weight standardization calculations. In addition, the zooplankton samples represent a wide variety of taxonomic groups which vary

dramatically seasonally, and even between replicate samples.

Windom (1972) points out another problem with trace metals analysis of zooplankton samples: the net collections can become contaminated by ship debris, particularly at the surface. Paint and rust chips off the sampling vessel and surrounding shipping activities can add high concentrations of certain metal to individual samples. It is believed that such a situation occurred in June of 1981 when a single zooplankton sample contained high levels of copper and iron, and to a lesser extent, lead and zinc. Considering the fact that many of the newer marine anti-fouling paints are copper based, the contamination of the sample with paint chips is not an unreasonable explanation for the aperiodic occurrence of extreme concentrations.

Regardless of the degree of variability in the data, most of the values observed for the representative biotic groups appeared to fall within the range of values reported previously for similar organisms taken from nearshore waters. Numerous articles have reviewed the topic of bioaccumulation of metals in marine species, (e.g. Eisler, 1973; Eisler and Wapner, 1975; Eisler et al. 1978; Phillips and Russo, 1978; Martin, 1979; Dillon, 1984; Bryan, 1984; and Eisler, 1984). Comparison of the overall patterns observed during the present study with those reviewed, indicate that the biota at the NDS are not contaminated by metals to an unexpected degree. All metal concentrations in biota were well below those

reported by Dillon (1984) as being the lowest levels shown to cause significant biological effects.

The fish samples contained fairly low levels of most metals (i.e., low ppm; mg/g). All metal concentrations were well within the ranges reported for a variety of fishes in the reviews by Bryan (1984) and Eisler (1984). Cadmium was generally below detection limits, conforming to a generalization made by Phillips and Russo (1978) "that very little cadmium is accumulated in the edible portions of fishes." The only metals that were observed to occur above 100 ppm were iron and zinc. However, the concentrations of these metals are not considered unusual. The high level observed were comparable with those which have been reported in fish collected from regions with "no known sources of contamination" (Phillips and Russo, 1978; Bryan, Eisler, 1984).

The levels of metals in the epibenthic macroinvertebrates were also fairly low (low ppm; mg/g). As with the fishes, the metals in the macroinvertebrates were well within the range of values reported in previous studies (Bryan, 1984; Eisler, 1984). Cadmium, chromium and lead were generally below detection limits. Copper values were higher in the invertebrates than the fishes, as has been reported previously (Phillips and Russo, 1979; Bryan, 1984; Eisler, 1984). The higher values of copper in _Cancer_ crabs and squid samples probably reflect the natural levels in respiratory pigments in the tissues. Zinc levels in the

macroinvertebrates were higher than in the fishes. These values were well within the range of concentrations described by Phillips (1980), as representing the defined levels to which decapods crustaceans regulate zinc body burdens.

The levels of most metals were higher in the zooplankton samples than in the other two groups. Although aperiodic contamination by abiotic debris is a possibility, the metal levels did not appear to be unreasonably high. These levels all fall within the range of metal values reported by Windom (1972) for zooplankton samples taken along the east coast of the U.S. The concentrations also fall well within the range of values reported for numerous other studies on single zooplankton species and total collections (Bryan, 1984; Eisler, 1984). The cadmium concentrations were below the levels reported for a series of zooplankton collections taken off the Pacific coast (Martin and Broenkow, 1975). Martin (1975) reports that mixed zooplankton samples often have extremely high concentration factors for heavy metals and that this community may play a significant role in the cycling of metals in the oceans.

The MDI levels for toxins in the vicinity of NDS were quite high compared to those obtained for water quality parameters (Alden, _et al_., 1984). On the other hand, most of the estimated "impacted" concentrations were moderately low, and those for tissues were always below the "highest no effects" levels reported for body

burdens (Dillon, 1984). The variability, high MDI levels and the low potential for statistical detection of moderate changes in body burden data are, to a large degree, associated with the diversity of species analyzed in each taxonomic group. As previously noted, many bioaccumulation patterns are species-specific. Therefore, more intensive biological collections of a few selected species would likely lower the variability and the MDI's. Unfortunately, the paucity of macrofaunal communities in the vicinity of the NDS would require an intensive sampling effort to collect sufficient biomass of the targeted species.

CONCLUSION

A study was conducted from 1981 to 1983 to characterize the toxins in water, sediment and biota collected in the vicinity of NDS. The levels of organic toxins (PNAH's and CHC's) in water were usually below detection limits. The metals in water were well within the range of concentrations reported for other coastal areas. Mercury values were elevated, but the source was unknown.

The levels of PNAH's and CHC's in sediments were very low. The PNAH's were below detection limits except for naphthalene, which was found in the low ppb range. Chlorinated pesticides in the sediments were found in low concentrations with DDT and its metabolities being the most common CHC's in the region. However, the concentrations of these chlorinated compounds were considered trace, with only a very subtle geographic pattern. The stations in the northeast quadrant of NDS had fewer of the CHC's above detection limits than the remaining stations. This region is the least affected by the Chesapeake Bay plume.

The organic toxins in biotic samples from NDS were extremely low (low ppb) or non-detectable. The PNAH's were seldom detected except in trace amounts. As with the sediment samples, the CHC's most often detected were DDT and its metabolities (primarily DDE). However, the concentrations were much lower than those reported from studies conducted about the time these compounds were banned in the U.S.

The concentrations of heavy metals in tissues of biota collected in the vicinity of the NDS were quite variable from season to season. This variability was due primarily to the varying species composition collected from the representative taxonomic groups. However, the levels of metals in the groups fell well within the ranges of values reported for similar organisms in previous studies. The fish tissues generally exhibited the lowest metals values, the macroinvertebrates had intermediate levels, while the zooplankton contained the highest concentrations. Even samples containing what appeared to be "elevated" levels of certain metals could be explained in terms of natural species-specific accumulation patterns.

In order to determine the effectiveness of the program in providing a baseline data against which future trend assessment data sets could be compared, a series of "minimum detectable impact" (MDI) values were calcuated. No MDI values could be estimated for organic toxins (PNAH's and CHC's) in water and tissues because these toxins below detection limits for all or most of the study. The MDI values for metals and the few organic toxins detected in sediments were quite high due to the variability of the data. However, the estimated lowest detectable impacted concentrations were usually quite low. The high MDI values for the highly variable bioaccumulation data did not raise the lowest detectable impacted concentrations above the levels

observed to cause significant biological effects in the laboratory. However, several of the MDI's for contaminant/toxin combinations were above the maximum level produced by the computer program (3000% change for single samples and 1000% for cruise means), so they could not be evaluated. It is recommended that future bioaccumulation studies focus a greater effort on acquiring sufficient biomass from a few target species to eliminate the interspecies variability which decreases the sensitivity of the trend assessment statistics.

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APPENDIX

Body burden of toxins in species of the NDS. For each species, the first row values are grand means, the second rows are the standrd errors and the third rows are the number of samples.

NORFOLK DISPOSAL SITE
METALS IN TISSUES BY SPECIES (mg/kg)
(continued)

SPECIES	Cd	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
Synodus foetens									
	1.9600	0.0000	15.2050	18.1000	19.5000	8.3300	18.2000	0.0000	56.7500
	.4400	0.0000	6.6950	4.3000	4.6000	3.1700	6.6000	0.0000	6.1500
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Urophycis chuss									
	1.0000	12.1000	3.6700	17.1000	0.0000	6.0200	1.7200	0.0000	21.5000
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Urophycis chuss liver									
	.5600	22.5000	33.6000	54.8000	3.2700	8.0400	.9600	0.0000	46.4000
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Urophycis regius									
	.7750	25.2500	9.3850	153.5350	14.4850	7.6550	9.6000	0.0000	94.6900
	.4589	12.0508	1.8010	72.3642	4.1344	5.5815	4.7776	0.0000	15.3087
	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
Eel									
	0.0000	6.1300	18.5500	124.9000	5.2750	11.4500	11.3500	0.0000	102.8500
	0.0000	.7800	.2500	2.7000	1.8450	1.0500	.5500	0.0000	4.3500
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Flounder									
	.1250	.8325	24.6225	41.8300	12.2850	11.2225	6.7425	0.0000	43.4025
	.1250	.8325	3.1342	11.6681	3.7182	2.6753	3.9001	0.0000	3.5548
	4.0000	4.0000	4.0600	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
Selved fluke									
	0.0000	0.0000	6.7500	59.1500	8.8000	15.1600	16.9500	0.0000	92.7500
	0.0000	0.0000	.5500	1.1500	1.5000	9.2400	2.8500	0.0000	33.1000
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Silver fluke									
	.3500	0.0000	2.6700	56.5067	.0633	.5267	3.6500	0.0000	18.6133
	.1916	0.0000	.2312	3.4104	.0088	.5267	3.6500	0.0000	.4361
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Squirrel fluke									
	0.0000	0.0000	2.4600	63.1100	.0700	2.2200	0.0000	0.0000	24.7400
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Spotted fluke									
	.4900	0.0000	8.4000	48.7600	10.8900	20.4200	13.7700	0.0000	48.0900
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Squid									
	.9233	6.8733	62.0333	23.7000	15.2733	40.0233	.5667	0.0000	73.7000
	.9233	6.5166	27.4874	2.3029	9.1057	32.5247	.5667	0.0000	16.0718
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Callinectes sapidus									
	.7300	0.0000	55.9900	8.4000	.9400	4.1400	9.6700	0.0000	300.3900
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Cancer irroratus									
	3.4429	16.5800	57.7571	241.2200	9.1371	9.4857	.6914	0.0000	145.2100
	1.7451	12.1511	17.4272	130.6845	5.3791	4.6225	.4777	0.0000	43.4445
	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000

NORFOLK DISPOSAL SITE
METALS IN TISSUES BY SPECIES (mg/kg)

SPECIES	Cd	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
Anchoa mitchilli									
	.5167	17.5067	6.8567	132.7100	13.2633	1.6600	5.5000	58.1333	203.3067
	.1139	3.4664	.6939	26.3357	8.4040	1.6600	2.5680	58.1333	22.7911
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Citharichthys sordidus									
	0.0000	0.0000	2.5800	43.4100	1.3200	0.0000	0.0000	0.0000	26.2400
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Etropus microstomus									
	1.0186	3.0057	17.2357	42.9857	19.2657	19.6729	7.6000	0.0000	61.4857
	.4797	1.4578	3.0510	8.8486	2.8296	10.9201	2.5705	0.0000	3.3800
	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	6.0000	7.0000
Lagodon rhomboides									
	.3400	2.3250	2.9350	38.7200	4.5900	0.0000	0.0000	0.0000	46.5650
	.1800	2.3250	.5750	.1500	1.6400	0.0000	0.0000	0.0000	1.6350
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Leiostomus xanthus									
	.0275	3.7975	3.0925	57.2650	11.8475	5.1375	10.9175	0.0000	71.1525
	.0275	2.8357	1.0059	11.4450	6.3576	2.2064	7.4516	0.0000	11.7692
	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
Merluccius bilinearis									
	.3120	15.1300	5.5720	129.7420	5.1820	3.7480	4.3620	0.0000	47.3760
	.2215	2.9705	.3035	32.7770	1.3286	1.3762	2.7483	0.0000	8.3663
	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000
Merluccius bilinearis liver									
	.6500	0.0000	10.7000	46.8000	0.0000	0.0000	1.1300	0.0000	0.0000
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Monacanthus hispidus									
	2.2700	0.0000	16.9000	198.0000	17.7000	7.2100	7.1500	0.0000	633.0000
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Peprilus triacanthus									
	.5717	12.3067	11.9300	100.2400	2.1333	7.9167	19.4367	0.0000	95.1300
	.2843	3.8042	6.8167	37.6218	1.2910	5.3249	13.5813	0.0000	19.7200
	6.0000	6.0000	6.0000	6.0000	6.0000	6.0000	6.0000	6.0000	6.0000
Pomatomus saltatrix									
	0.0000	11.0000	.5000	26.0000	.5000	5.0000	2.6000	0.0000	86.9000
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Prionotus evolans									
	.4600	2.7740	5.8180	50.3420	2.9480	2.5060	9.0860	0.0000	41.5600
	.2636	.9867	2.5120	10.8729	.8168	1.2922	4.6529	0.0000	10.9601
	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	4.0000	5.0000
Scophthalmus aquosa									
	.3033	1.2300	15.3200	41.2000	9.9900	54.6200	11.1200	0.0000	68.9667
	.3033	1.2300	5.7850	13.7863	5.8004	24.6370	10.3499	0.0000	20.6321
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Stenotomus chrysops									
	.7300	0.0000	31.7500	56.3200	6.1000	3.7000	20.3300	0.0000	59.4400
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	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

NORFOLK DISPOSAL SITE
METALS IN TISSUES BY SPECIES (mg/kg)
(continued)

SPECIES	Cd	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
Libinia emarginata									
	0.0000	0.0000	50.4500	109.2000	6.5300	0.0000	6.2200	0.0000	204.9300
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Ovalipes ocellatus									
	.3867	3.8900	31.3233	28.7467	.0533	2.1833	0.0000	0.0000	109.1733
	.2379	2.8698	14.6332	12.2521	.0533	1.2792	0.0000	0.0000	34.0462
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Shrimp									
	.4550	18.0000	52.4000	70.0000	7.1000	3.9500	13.5500	5.5000	109.6500
	.4550	3.0000	1.2000	2.0000	.9000	3.9500	4.3500	5.5000	8.2500
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Knobbed whelk									
	.5800	0.0000	24.4900	57.6000	0.0000	1.6750	0.0000	0.0000	48.5100
	.4600	0.0000	9.2000	10.5400	0.0000	1.6750	0.0000	0.0000	21.6400
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Channeled whelk									
	.4333	0.0000	62.7633	75.6533	0.0000	2.7567	0.0000	0.0000	139.9200
	.0733	0.0000	14.3216	3.5281	0.0000	1.9119	0.0000	0.0000	80.0549
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Zooplankton									
	1.3890	59.4635	123.5079	2412.0483	52.6286	18.8622	53.7338	2.1358	1205.5407
	.2935	28.4895	65.2394	370.3824	7.0856	5.5781	16.3413	1.2288	165.5297
	72.0000	72.0000	71.0000	72.0000	72.0000	72.0000	72.0000	72.0000	54.0000

NORFOLK DISPOSAL SITE
PNAH's IN TISSUES BY SPECIES (ng/g)

SPECIES	N	Acy	Acn	F	Ph	A	Fl	Pyre	B(a)A
<u>Anchoa mitchilli</u>									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	—	—	—	—	—	—	—	—	—
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
<u>Citharichthys sordidus</u>									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	—	—	—	—	—	—	—	—	—
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
<u>Etropus microstomus</u>									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	—	—	—	—	—	—	—	—	—
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
<u>Menidia menidia</u>									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
<u>Merluccius bilinearis</u>									
	7881.5269	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	4778.9955	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	6.0000	6.0000	6.0000	6.0000	6.0000	6.0000	6.0000	6.0000	6.0000
<u>Rissola marginata</u>									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	—	—	—	—	—	—	—	—	—
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
<u>Scophthalamus aquosa</u>									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
<u>Stenotomus chrysops</u>									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	—	—	—	—	—	—	—	—	—
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Triglidae family									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
<u>Urophycis chuss</u>									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000
<u>Urophycis regius</u>									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Eel									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	—	—	—	—	—	—	—	—	—
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Flounder									
	359.0437	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	336.6672	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000

NORFOLK DISPOSAL SITE
PNAH's IN TISSUES BY SPECIES (ng/g)
(continued)

SPECIES	N	Acy	Acn	F	Ph	A	Fl	Pyre	B(a)A
Flounder liver									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Flounder muscle									
	83.7257	0.0000	104.0612	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	83.7257	0.0000	104.0612	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Squirrel hake									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Misc. small fish									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Cancer irroratus									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000
Crab									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Shrimp									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Knobbed whelk									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Channeled whelk									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Rock crab									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Rock crab liver									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Rock crab internal organs									
	859.6961	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Zooplankton									
	89.9714	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	82.5843	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	36.0000	36.0000	36.0000	36.0000	36.0000	36.0000	36.0000	36.0000	36.0000

NORFOLK DISPOSAL SITE
PNAH's IN TISSUES BY SPECIES (ng/g)
(continued)

SPECIES	Ch	DiB(a,h)A	B(ghi)P	B(a)P	B(b)F	B(k)F	I
Anchoa mitchilli							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	—	—	—	—	—	—	
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Citharichthys sordidus							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	—	—	—	—	—	—	
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Etropus microstomus							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	—	—	—	—	—	—	
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Menidia menidia							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Merluccius bilinearis							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	6.0000	6.0000	6.0000	6.0000	6.0000	6.0000	6.0000
Rissola marginata							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	—	—	—	—	—	—	
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Scopthalamus aquosa							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Stenotomus chrysops							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	—	—	—	—	—	—	
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Triglidae family							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Urophycis chuss							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000
Urophycis regius							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Eel							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	—	—	—	—	—	—	
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Flounder							
	0.0000	0.0000	0.0000	0.0000	41.5902	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	41.5902	0.0000	0.0000
	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000

NORFOLK DISPOSAL SITE
PNAH's IN TISSUES BY SPECIES (ng/g)
(continued)

SPECIES	Ch	DiB(a,h)A	B(ghi)P	B(a)P	B(b)F	B(k)F	I
Flounder liver							
	0.0000	0.0000	2339.0977	0.0000	2272.1805	0.0000	0.0000
	--	--	--	--	--	--	
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Flounder muscle							
	0.0000	0.0000	311.9629	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	311.9629	0.0000	0.0000	0.0000	0.0000
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Squirrel hake							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	--	--	--	--	--	--	
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Misc. small fish							
	0.0000	0.0000	179.9641	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	179.9641	0.0000	0.0000	0.0000	0.0000
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Cancer irroratus							
	83.5391	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	83.5391	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000
Crab							
	44.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	44.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Shrimp							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Knobbed whelk							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Channeled whelk							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Rock crab							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	--	--	--	--	--	--	
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Rock crab liver							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
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	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Rock crab internal organs							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
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	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Zooplankton							
	0.0000	0.0000	0.0000	0.0000	112.5993	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	78.5569	0.0000	0.0000
	36.0000	36.0000	36.0000	36.0000	36.0000	36.0000	36.0000

NORFOLK DISPOSAL SITE
PESTICIDES IN TISSUES BY SPECIES (ng/g)

SPECIES	BHC	LINDANE	ALDRIN	Hep Epox	KEPONE	OPDDT	PPDDD	PPDDT	PPDDE
Anchoa mitchilli									
	0.0000	0.0000	.0467	0.0000	0.0000	.4467	.2200	.7167	.4467
	0.0000	0.0000	.0467	0.0000	0.0000	.4467	.2200	.7167	.2238
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Citharichthys sordidus									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Lagodon rhomboides									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0350
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0150
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Leiostomus xanthus									
	2.1260	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	14.0080
	2.1260	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	13.9930
	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000
Menidia menidia									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Merluccius bilinearis									
	4.7514	4.1386	0.0000	1.6500	44.7500	.0043	10.2343	0.0000	62.3329
	4.7498	2.7994	0.0000	1.6500	34.7769	.0043	7.6127	0.0000	35.2907
	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000
Merluccius bilinearis liver									
	2.5600	0.0000	0.0000	0.0000	0.0000	0.0000	359.7900	0.0000	0.0000
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	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Peprilus triacanthus									
	.0033	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0333
	.0033	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0125
	6.0000	6.0000	6.0000	6.0000	6.0000	6.0000	6.0000	6.0000	6.0000
Pomatomus saltatrix									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.1075
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0295
	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
Prionotus evolans									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Rissola marginata									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
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	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Scopthalamus aquosa									
	.0050	0.0000	0.0000	.0050	0.0000	0.0000	0.0000	0.0000	.0250
	.0050	0.0000	0.0000	.0050	0.0000	0.0000	0.0000	0.0000	.0250
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Stenotomus chrysops									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
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	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

NORFOLK DISPOSAL SITE
PESTICIDES IN TISSUES BY SPECIES (ng/g)
(continued)

SPECIES	δBHC	LINDANE	ALDRIN	Hep Epox	KEPONE	OPDDT	PPDDD	PPDDT	PPDDE
Urophycis chuss									
	3.2000	4.7140	0.0000	.0260	13.8000	0.0000	1.3820	0.0000	55.3380
	2.6677	4.7115	0.0000	.0166	13.8000	0.0000	1.3820	0.0000	36.1370
	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000
Urophycis chuss liver									
	5.7200	54.4600	0.0000	0.0000	0.0000	0.0000	114.2000	0.0000	770.0000
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Urophycis regius									
	5.0670	0.0000	0.0000	9.4880	11.0240	0.0000	3.5970	0.0000	8.7470
	4.2005	0.0000	0.0000	9.4880	11.0240	0.0000	3.5970	0.0000	6.[illegible]
	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000
Eel									
	0.0000	0.0000	0.0000	0.0000	0.0000	.1600	.1200	.3200	0.0000
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Flounder									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0400
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0209
	9.0000	9.0000	9.0000	9.0000	9.0000	9.0000	9.0000	9.0000	9.0000
Flounder liver									
	80.1600	21.6500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	149.5500
	37.3700	21.6500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	149.5500
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Flounder muscle									
	2.5333	0.0000	0.0000	0.0000	20.7133	0.0000	0.0000	0.0000	8.3700
	1.5711	0.0000	0.0000	0.0000	20.7133	0.0000	0.0000	0.0000	8.3701
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Squirrel hake									
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
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	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Misc. small fish									
	7.5300	0.0000	0.0000	0.0000	58.4500	0.0000	0.0000	0.0000	0.0000
	1.4100	0.0000	0.0000	0.0000	4.2600	0.0000	0.0000	0.0000	0.0000
	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Cancer irroratus									
	3.1789	.2689	0.0000	.2011	0.0000	0.0000	0.0000	0.0000	5.0244
	2.1000	.2689	0.0000	.2011	0.0000	0.0000	0.0000	0.0000	3.4940
	9.0000	9.0000	9.0000	9.0000	9.0000	9.0000	6.0000	9.0000	9.0000
C. irroratus muscle									
	40.1300	64.2400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	263.9700
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
C. irroratus internal organs									
	53.9800	11.4200	0.0000	16.6100	1198.9600	30.4500	0.0000	0.0000	0.0000
	--	--	--	--	--	--	--	--	--
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Crab									
	.0057	.0067	.0242	0.0000	0.0000	0.0000	0.0000	0.0000	.0133
	.0047	.0051	.0119	0.0000	0.0000	0.0000	0.0000	0.0000	.0111
	12.0000	12.0000	12.0000	12.0000	12.0000	12.0000	12.0000	12.0000	12.0000

NORFOLK DISPOSAL SITE
PESTICIDES IN TISSUES BY SPECIES (ng/g)
(continued)

SPECIES	δBHC	LINDANE	ALDRIN	Hep Epox	KEPONE	OPDDT	PPDDD	PPDDT	PPDDE
Knobbed whelk									
	0.0000	0.0000	0.0000	0.0000	0.0000	.0433	.0633	0.0000	.0267
	0.0000	0.0000	0.0000	0.0000	0.0000	.0145	.0240	0.0000	.0067
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Channeled whelk									
	0.0000	0.0000	0.0000	0.0000	0.0000	.0133	0.0000	.0167	.0067
	0.0000	0.0000	0.0000	0.0000	0.0000	.0133	0.0000	.0167	.0067
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Shrimp									
	6.0033	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	283.4767
	6.0033	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	179.1878
	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Zooplankton									
	.4346	.0109	.0104	23.2917	0.0000	60.3602	.0013	46.9480	46.3646
	.4297	.0056	.0065	23.2879	0.0000	60.2710	.0013	33.9824	46.3490
	54.0000	54.0000	54.0000	54.0000	54.0000	54.0000	52.0000	54.0000	54.0000

NORFOLK DISPOSAL SITE
PESTICIDES IN TISSUES BY SPECIES (ng/g)
(continued)

SPECIES	BBHC	DIELDRIN	Heptachlor
Anchoa mitchilli			
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Citharichthys sordidus			
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	------	------	------
Lagodon rhomboides			
	------	------	------
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	------	------	------
Leiostomus xanthus			
	6.1300	0.0000	7.1200
	--	--	--
	1.0000	1.0000	1.0000
Menidia menidia			
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Merluccius bilinearis			
	25.6775	0.0000	.0075
	15.5270	0.0000	.0075
	4.0000	4.0000	4.0000
Merluccius bilinearis liver			
	0.0000	0.0000	0.0000
	--	--	--
	1.0000	1.0000	1.0000
Peprilus triacanthus			
	------	------	------
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	------	------	------
Pomatomus saltatrix			
	------	------	------
	------	------	------
	------	------	------
Prionotus evolans			
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	------	------	------
	------	------	------
Rissola marginata			
	------	------	------
	------	------	------
	------	------	------
Scophthalmus aquosa			
	0.0000	0.0000	.0200
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	1.0000	1.0000	1.0000
Stenotomus chrysops			
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NORFOLK DISPOSAL SITE
PESTICIDES IN TISSUES BY SPECIES (ng/g)
(continued)

SPECIES	BBHC	DIELDRIN	Heptachlor
Urophycis chuss			
	21.1350	0.0000	0.0000
	17.2887	0.0000	0.0000
	4.0000	4.0000	4.0000
Urophycis chuss liver			
	157.1500	0.0000	0.0000
	--	--	--
	1.0000	1.0000	1.0000
Urophycis regius			
	23.3833	0.0000	2.3250
	16.9667	0.0000	2.3250
	3.0000	2.0000	2.0000
Eel			
	------	------	------
	------	------	------
	------	------	------
Flounder			
	------	------	------
	------	------	------
	------	------	------
Flounder liver			
	160.3100	0.0000	6.9600
	160.3100	0.0000	6.9600
	2.0000	2.0000	2.0000
Flounder muscle			
	0.0000	16.9767	0.0000
	0.0000	9.5700	0.0000
	3.0000	3.0000	3.0000
Squirrel hake			
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	------	------	------
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Misc. small fish			
	0.0000	68.4200	0.0000
	0.0000	5.9300	0.0000
	2.0000	2.0000	2.0000
Cancer irroratus			
	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000
	6.0000	6.0000	6.0000
C. irroratus muscle			
	0.0000	0.0000	0.0000
	--	--	--
	1.0000	1.0000	1.0000
C. irroratus internal organs			
	0.0000	685.8100	0.0000
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	1.0000	1.0000	1.0000
Crab			
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NORFOLK DISPOSAL SITE
PESTICIDES IN TISSUES BY SPECIES (ng/g)
(continued)

SPECIES	BBHC	DIELDRIN	Heptachlor
Knobbed whelk			
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Channeled whelk			
	------	------	------
	------	------	------
	------	------	------
Shrimp			
	9.6167	0.0000	------
	4.8090	0.0000	------
	3.0000	3.0000	------
Zooplankton			
	.0427	570.5164	.0382
	.0190	497.1010	.0186
	11.0000	11.0000	11.0000

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